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AUTHOR(S):

Takaya, Yoshikazu

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## **Quaternary Outcrops of the Southern Part of the Central Plain of Thailand**

by

Yoshikazu TAKAYA\*

### **Introduction**

The purpose of this paper is to describe 60 representative Quaternary outcrops of the southern part of the Central plain of Thailand. This paper, thus, makes a pair with the preceding paper "Quaternary Outcrops in the Central plain of Thailand, 1968"<sup>1)</sup> which mainly dealt with the northern part of the same plain. Stratigraphical as well as depositional analyses of the sediments rely greatly upon chemical and mineralogical studies made by T. Hattori. Hattori's report which appears in the same issue of this journal, therefore, should be fully referred.

### **I A geomorphic setting of the southern part of the Central plain**

The southern part of the Central plain of Thailand consists of four physiographic areas, i.e. the old delta of the Chao Phraya, the recent delta of the Chao Phraya, calcareous area and fan complex area which skirts the former three.

The old delta has a slightly undulating ground surface covered with slightly weathered materials. The surface inclines very gently towards south, having an elevation ranging from 15 to 5 m above MSL and has conspicuous topographical break along the border with the recent delta.

The recent delta has very flat ground surface, most of which is approximately 2 m above MSL, with some exceptionally elevated parts which attain more than 3.5 m above MSL.

The calcareous area is located in the northeastern corner of the plain, revealing moderate to strongly undulating ground surface. The area appears like a remnant of older terrain than Pleistocene, whose original components have been heavily weathered, decomposed and replaced by calcareous materials during sometime in Quaternary.

The fan complex area has steep general slope toward the center of the plain. Geomorphologically this consists of fans, cones, terraces and erosional surfaces of varying ages. A rough distribution map of the four areas is shown in Fig. 1.

\* The Center for Southeast Asian Studies, Kyoto University

Extrapolating the stratigraphy which is established in the northern part of the Central plain, four clastic formations of different ages and one stratigraphically unknown formation are provisionally proposed in the southern part of the plain as well. These are :

sediments	weathering degree	provisional age
Formation I	no severe weathering	post glacial
II	pisolitic iron concretions in the near-surface 1 to 2 m thick	last interglacial
III	thin (1-10 cm) lateritic top layer	penultimate interglacial
Laterite Formation	thick (1-5 m) lateritization	?
Calcareous Form.	secondary deposited calcareous material	recent to ?

## II Description of Outcrops

[Some remarks on the description of outcrops]

### Locality

Location of each outcrop is shown by a locality number on a locality map of Fig. 1. The locality numbers start from 141, the reason being that the localities from No. 1 to No. 140 are in the northern part of the Central plain and have already been described in the previous paper.<sup>1)</sup>

### Ground height

No special survey was made for determining the elevation of locality, so the height recorded here is no more accurate than can be assessed from the 1 : 50,000 topographical map of series L-708.

### Color of materials

The Munsel's color chart was used.

### Stratigraphical horizon

At the end of the description of each geological unit, a probable stratigraphical horizon is shown by an abbreviation as follows;

(BC)	Black clay*
(I)	Formation I
(II)	Formation II
(III)	Formation III
(Lat)	Laterite Formation
(Cal)	Calcareous Formation

\* In the deltaic area, ground surface or near ground surface layers some ten centimeter thick are often made up of black colored clayey sediments. Though these sediments are very thin and most of them should be included in the Formation I, they are categorized separately under the name of Black clay (BC) in the description, because of

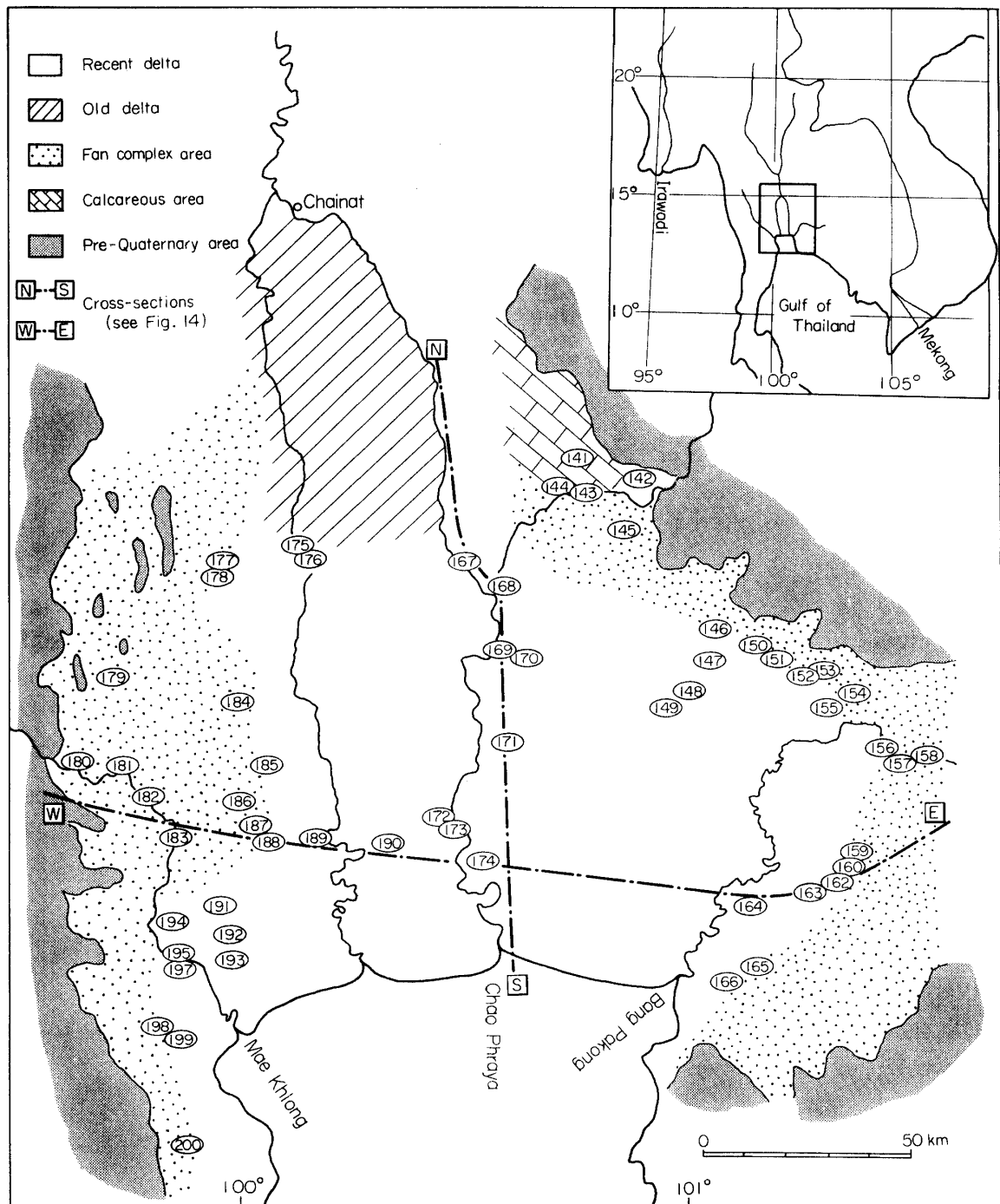


Fig. 1 Locality map of the outcrops described in the paper

their very wide distribution and characteristic nature.

Code number to refer Hattori's information<sup>3)</sup>

Code numbers, by which Hattori's chemical information be referred, are shown by (H:....) at the end of description.

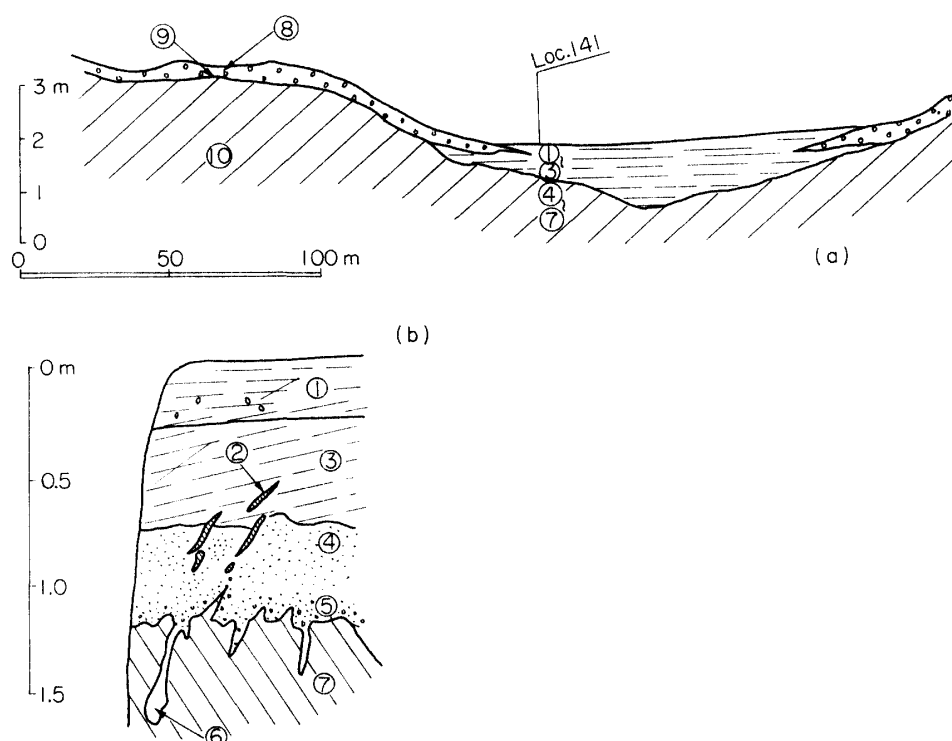
# Abbreviations

(texture)	heavy : H	light : Li
	clay : C	loam : L
	silt : Si	sand : S
(color)	yellow : yl	brown : br
	gray : gr	white : wh
	calcareous : Ca	manganese : Mn
(others)	iron : Fe	in dry condition : d
	in moist condition : m	in wet condition : w
	mottlings : mott	ground height : G.H.

**Loc. 141:** Marl quarry of Siam Cement Co.; 14° 38' 10" N, 100° 45' 10" E

G. H.: ca 13 m; undulating brush land (see Figs. 2a & b)

- 1) Black (N 2, w) HC; fine angular blocky; very few extraneous calcareous concretions
- 2) Fissure fillings mostly composed of Ca-nests
- 3) Very dark br (10YR 2/2, m) HC; very few Mn-pisoliths ( $\phi$ 2-4 m/m); very few Ca-nests; many slickensides; more friable than (4)
- 4) Very similar to (3), but more stiff
- 5) Gr-br (10YR 5/2, m) HC; profuse Mn-pisoliths; common Ca-nests and concretions; less slickensides than (4)



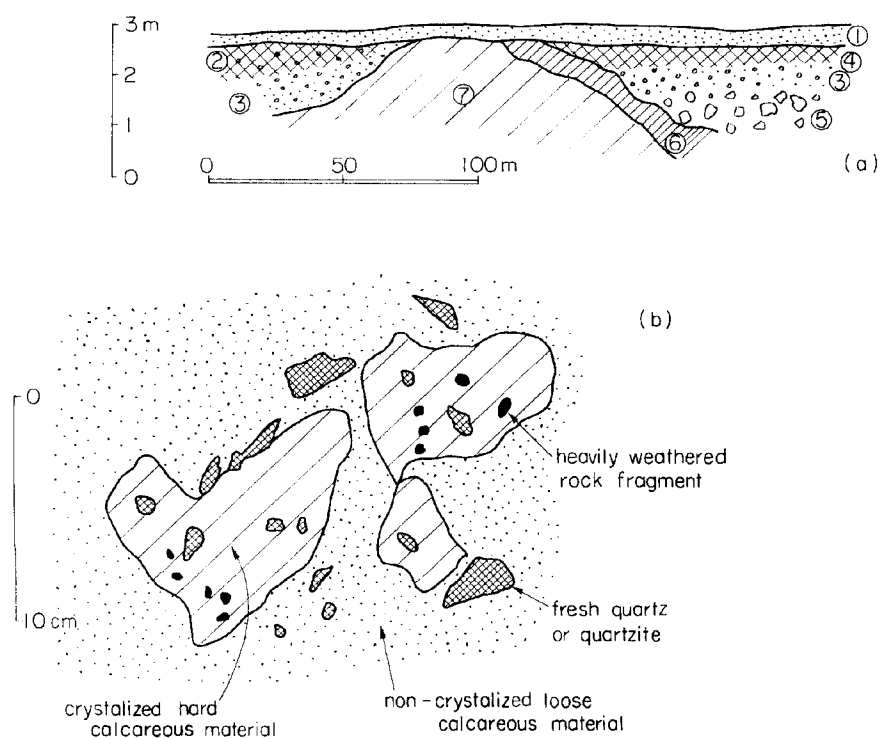
**Fig. 2-a and 2-b** Sketches of outcrops of calcareous deposits at and near Loc. 141

- 6) Fissure fillings composed of (5)
- 7) Mixture of wh(10YR 8/2, m) C and Ca-nodules; very few dark yl-br (10YR 6/6) small cloudy mott; [Cal]
- 8) Very dark br (7.5YR 2/2, d) HC; many to profuse Ca-nodules and spots; granular to small blocky; friable
- 9) Dark br (7.5YR 3/4, d) LiC; profuse Ca-nodules; small blocky
- 10) Similar to (7) [Cal]

**Loc. 142:** ca 9 km N of Changwat Sara Buri; 14° 36' 50" N, 100° 58' 50" E

G. H.: ca 25 m; slightly undulating upland crop field (see Figs. 3a & b)

- 1) Dark gr L (disturbed horizon)
- 2) Fe-cemented pebbles; most pebbles are fresh
- 3) Aggregate of various gravels and coarse sand including many irregular shaped Fe-coated rock fragments, well rounded Fe-pisoliths and Mn-pisoliths
- 4) Pale red (2.5YR 6/2, d) CI; common red (10R 4/8) spots and their aggregates; few small Fe- and Mn-concentrations ( $\phi$  1-3 m/m); few red-yl (7.5YR 7/6) small cloudy mott; columnar structure
- 5) Angular to subangular gravel; loosely cemented by Fe-materials
- 6) Ca-crust; detail is shown in Fig. 3-b
- 7) Mixture of wh (10YR 8/2, d) C and Ca-concretions and nodules; very similar to the (7) of Loc. 141 [Cal]



**Fig. 3-a** A sketch of an outcrop in calcareous area, at Loc. 142

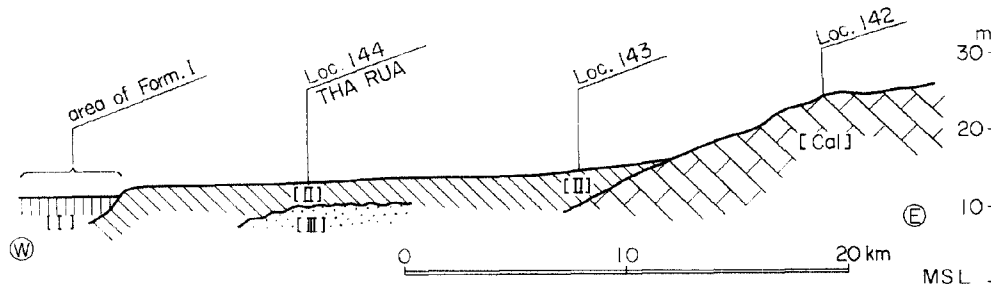
**Fig. 3-b** A sketch of a specimen of unit ⑥ in Fig. 3-a

**Loc. 143:** ca 10 km NW of Changwat Sara Buri, 14° 35' 20" N, 100° 49' 40" E

G. H.: 15 m; undulating rice land (see Fig. 4)

- Surface-0.1 m: Dark gr-br (10YR 4/2, d) HC; common to many red-yl (7.5YR 7/8) fibrous and filmy mott; few extraneous Fe-pisoliths; blocky (Ploughed layer)
- 0.1-0.2 m: Yl-br (10YR 5/4, m) HC; common to many yl-red to red-yl cloudy mott; few Mn-films; common extraneous Fe-pisoliths ( $\phi$  2-3 m/m) [I]; gradual to

- 0.2–0.4 m: Yl-red (5YR 5/8, m) and gr-br (10YR 5/2, m) mixed HC; common extraneous Fe-pisoliths ( $\phi$  2–6 m/m); [I]; gradual to
- 0.4–0.6 m: Br (7.5YR 4/2, m) HC; common extraneous Fe-pisoliths ( $\phi$  3–7 m/m); profuse yl-red (5YR 5/6) to red-yl (5YR 6/8) spots; few Mn-concentrations; [I]; clear to
- 0.6–1.4 m: Br (7.5YR 5/2, m) HC; common red-yl (7.5YR 6/8) cloudy mott and concentrations; common Fe-pisoliths ( $\phi$  3–7 m/m); large blocky; [II]; gradual to
- 1.4–1.6 m: Yl-br (10YR 5/4, m) HC; few gr-br (10YR 5/2) mott; few Fe-pisoliths ( $\phi$  2–4 m/m); many slickensides [II]



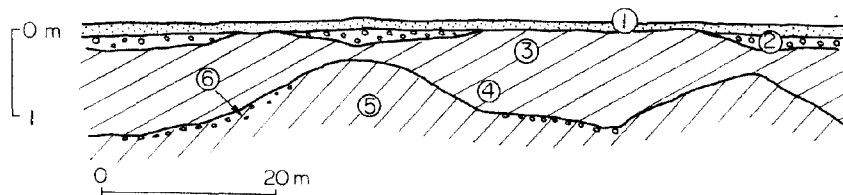
**Fig. 4** An E-W cross-section parallel to the Pasak river, on the northern bank

**Loc. 144:** ca 4 km NEE of Amphoe Tha Rua;  $14^{\circ} 34' 40''$  N,  $100^{\circ} 46' 00''$  E  
G. H.: ca 13 m; undulating rice land

- Surface–4.0 m: Unknown, but probably [II]
- 4.0–4.4 m: Very dark gr (N 3, d) HC; few Fe-pisoliths ( $\phi$  2–5 m/m); few Ca-concretions ( $l < 15$  m/m); strong slickensides; sharp boundary to
- 4.4–4.7 m: Pinkish gr (7.5YR 7/2, d) C; profuse Ca-nodules ( $\phi$  5–15 m/m); very few Mn-pisoliths ( $\phi$  2–4 m/m); very few Fe-pisoliths ( $\phi$  2–5 m/m); gradual to
- 4.7–4.9 m: Similar to the above, but less Ca-nodules and less Mn- and Fe-pisoliths; [II] very sharp to
- 4.9–6.4 m: Red-yl (7.5YR 6/8, m) indurated HC; many cracks which are filled with pinkish gr (7.5YR 5/2) C and Ca-nodules ( $\phi < 10$  cm); [III]

**Loc. 145:** ca 11 km SW of Changwat Sara Buri;  $14^{\circ} 27' 00''$  N,  $100^{\circ} 50' 30''$  E  
G. H.: ca 10 m; slightly undulating wooded rice land (see Fig. 5)

- 1) Light yl-br (10YR 6/4, d) SCL; common red-yl (7.5YR 6/8) fibrous and filmy mott; very few extraneous Fe- and Mn-pisoliths; sharp to
- 2) Aggregate of pisolitic and irregular shaped Fe-concretions with wh (10YR 8/2, d) SL matrix; sharp to
- 3) Red-gr (5YR 5/2, d) HC; common br (7.5YR 5/4) cloudy mott; common heavily weathered rock fragments of coarse grain size and/or Fe-pisoliths (II or III); sharp and uneven boundary, often forming interfinger with



**Fig. 5** A sketch of an outcrop of the upper part of fan type deposits at Loc. 145. Similar sediments extend westwards more than 15 km beyond the Phachi station and then submerge under the younger clays of Formation I

- 4) Red-gr (5YR 5/2, d) and red-yl (5YR 6/6) finely mixed LiC; common heavily weathered rock fragments of coarse grain size; common Fe-coated Mn-pisoliths ( $\phi$  3–5 m/m); [II or III]; sharp and uneven boundary to, often forming interfinger with
- 5) Red-br (10YR 5/4, d) LiC; few Ca-nodules; few Mn-pisoliths ( $\phi$  2–6 m/m); [II or III]
- 6) Pocket of Ca-nodules ( $\phi$  3–15 m/m) and Mn-pisoliths ( $\phi$  2–7 m/m)

**Loc. 146:** 0.5 km S of Amphoe Ban Na; 14° 15' 30" N, 101° 05' 30" E  
G. H.: ca 4 m; in town (see Fig. 6)

Surface-0.3 m: Disturbed SL

0.3–0.8 m: Wh (10YR 8/2, d) SCL; few red-yl (7.5YR 7/8) fibrous and cloudy mott; sharp to

0.8–1.4 m: Br (7.5YR 5/2, m) SCL; common to many red (2.5YR 4/8) and yl (10YR 7/8) mixed and diffused cloudy mott; few gr-br (10YR 5/2) sandy lenses; sharp to

1.4–2.1 m: Alternated layers of wh (10YR 8/2, m) S and gr-br (10YR 5/2) C; common feldspar grains in the sandy parts; few br (7.5YR 5/4) concretionary mott in the clay part; sharp to

2.1–2.6 m: Gr-br (10YR 5/2, m) HC; few S lenses with red (2.5YR 5/8) distinct and yl (2.5Y 7/8) diffused mott; blocky; sharp

2.6–3.0 m: Gr (N 6, w) coarse S; many feldspar grains; very few red-yl (7.5YR 6/8) fibrous mott; sharp to

3.0–4.4 m: Alternated layers of C and S

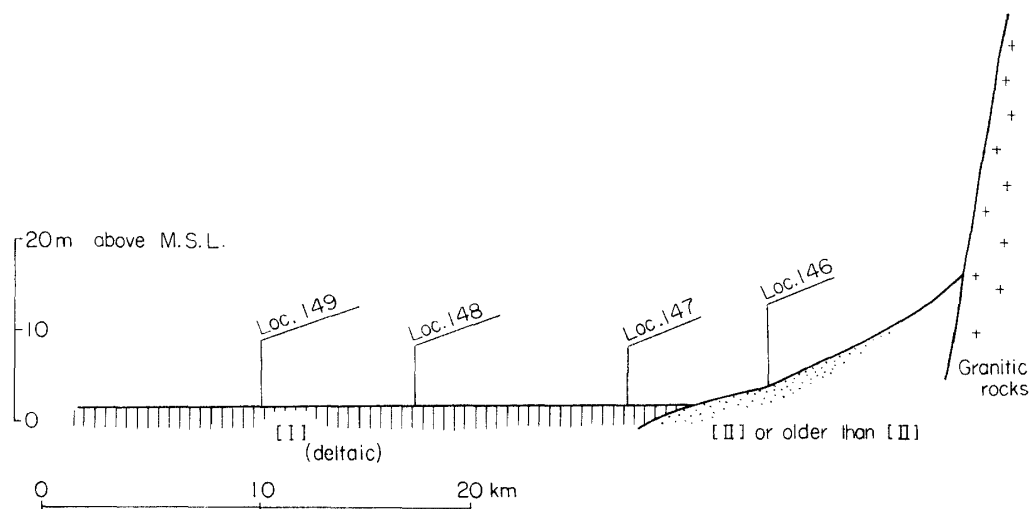
The entire succession is interpreted as a part of fan deposits from eastern hills.

**Loc. 147:** ca 7 km S of Amphoe Ban Na; 14° 11' 50" N, 101° 03' 30" E  
G. H.: ca 2 m; flat rice land (see Fig. 6)

Surface-0.4 m: Very dark gr (N 3, m) CL; few dark yl-br (10YR 4/4) fibrous and cloudy mott; blocky; [BC]; (H: 147-1)

0.4–0.5 m: Black (N 2, m) HC; porous; prismatic; [BC]; (H: 147-2)

0.5–0.6 m: Pale red (2.5YR 6/2, m) LiC; few red (2.5YR 4/8), few red-yl (7.5YR 6/8) and few br-yl (10YR 6/6) films and fibrous mott; blocky; [I]; (H: 147-3)



**Fig. 6** A NE-SW cross-section showing the relationship between the recent and other formations, on the eastern margin of the recent delta



**Loc. 148:** ca 1 km N of Amphoe Ongkharak; 14° 08' 00" N, 101° 00' 10" E  
G. H.: ca 2 m; flat tree-less rice land (see Fig. 6)

Surface–0.1 m: Black C; [BC]  
0.1–0.6 m: Pinkish gr (7.5YR 6/2, m) HC; common to many red (10R 4/8 and 5/8) cloudy mott; common yl (10YR 7/8) fibrous mott; [I]; (H: 148–1); gradual to  
0.6–0.9 m: Light br-gr (10YR 6/2, m) HC; few to common yl (10YR 8/8) pipes and fibrous mott; [I]; (H: 148–2)

**Loc. 149:** ca 6 km SWW from Ongkharak along khlong Rangsit; 14° 06' 10" N, 100° 58' 10" E  
G. H.: ca 2 m; flat tree-less rice land (see Fig. 6)

Surface–0.3 m: Olive gr (7.5Y 4/2, m) LiC; few yl-red (5YR 4/8) fibrous mott; very few red (2.5YR 4/8) films; (H: 149–1); sharp to  
0.3–0.5 m: Black (N 2, m) LiC; very few strong br (7.5YR 5/8) fibrous mott; few pinkish gr (7.5YR 6/2) C lenses; [BC]; (H: 149–2); uneven but clear to  
0.5–0.8 m: Dark br (7.5YR 4/2, m) LiC; very few strong br (7.5YR 4/6) fibrous mott; black (N 2) C fillings in desiccation cracks; [I]; (H: 149–3); gradual to  
0.8–1.1 m: Pinkish gr (7.5YR 7/2, m) LiC; few to common yl (10YR 7/8) filmy mott; very few dark br (7.5YR 3/4) filmy mott; [I]; (H: 149–4)

**Loc. 150:** ca 8 km W of Changwat Nakhon Nayok; 14° 13' 20" N, 101° 08' 50" E  
G. H.: ca 3 m; flat tree-less rice land

Surface–0.5 m: Dark br (7.5YR 4/2, d) LiC; very few red-yl (7.5YR 6/8) and yl (10YR 7/8) pipes and fibrous mott; (H: 150–1)  
0.5–0.7 m: Black (N 2, m) LiC; blocky; [BC]  
0.7–0.8 m: Pinkish gr C; no mott; [I]  
0.8–1.0 m: Pinkish gr C; common red mott; few yl mott which increase downwards; [I]; (H: 150–3)  
Dredged material from deeper horizon: Pinkish gr (5YR 7/2, d) fine S; few red-yl (7.5YR 6/6) and strong-br (7.5YR 5/8) fibrous mott

**Loc. 151:** ca 1 km W of Changwat Nakhon Nayok; 14° 12' 10" N, 101° 12' 40" E  
G. H.: ca 3 m; flat tree-less rice land

Surface–0.3 m: Disturbed and sloppy layer  
0.3–0.6 m: Pinkish gr (5YR 7/2 and 2.5YR 7/2, m) CL; few strong br (7.5YR 4/6) small to medium cloudy mott; few red-br (2.5YR 3/4) films; [I]; (H: 151–1)

**Loc. 152:** ca 1 km E of Amphoe Pak Phli; 14° 09' 40" N, 101° 16' 20" E  
G. H.: ca 5 m; border between slightly undulating wooded rice land and flat tree-less rice land (see Fig. 7)

Surface–0.3 m: Wh SC; common to many extraneous Fe-concretions; (H: 152–1) sharp to  
0.3–0.6 m: Very dark gr (N 3, m) HC; few red (2.5YR 4/8) and strong br (7.5YR 4/8) mott; very few plant remains; [BC]; (H: 152–2); clear to  
0.6–1.2 m: Light gr (10YR 7/2, d) SL; few red (2.5YR 4/8) cloudy mott; few Fe-replaced (red colored) plant roots in growing position; few darker colored C lenses; [I]; (H: 152–3); gradual to  
1.2–1.7 m: Very similar to the above, but the mott and Fe-pipes are many to profuse; [I]; (H: 152–4)

**Loc. 153:** ca 5 km SEE of Amphoe Pak Phli; 14° 09' 00" N, 101° 18' 30" E  
G. H.: ca 8 m; slightly undulating wooded rice land

Surface–0.4 m: Pinkish gr (5YR 7/2, d) S; few red-yl (7.5YR 6/8) fibrous mott; (H: 153–1); sharp to

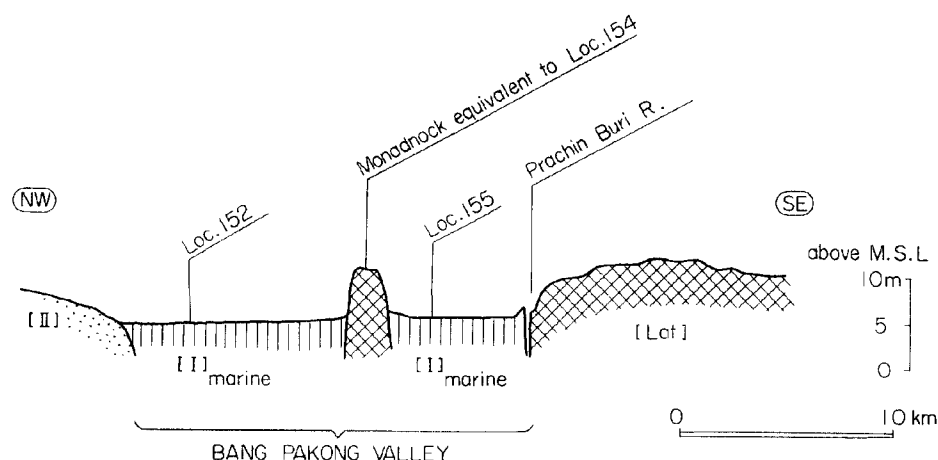
- 0.4–0.7 m: Wh (10YR 8/2, m) S; common to many dark red (10R 3/6) concretionary mott; (H: 153–2)  
 0.7–1.4 m: Wh (N 8, d) HC; common large red (7.5R 6/4) concretionary mott; common yl (10YR 8/8) fibrous and concretionary mott; (H: 153–3)  
 1.4–1.9 m: Mosaic of red (7.5R 4/8, d) indurated C and wh (N 8, d) slightly indurated C; (H: 153–4); uneven boundary to  
 1.9–2.7 m: Wh (7.5Y 8/2, d) indurated C; very few weak red (7.5R 5/4) spots; many black colored minerals; (H: 153–5)

**Loc. 154:** ca 8 km NW of Prachin Buri; 14° 06' 20" N, 101° 19' 50" E  
 G. H.: ca 12 m; bruch covered monadnock

- Surface–1.5 m: Very pale br C with many quartz grains; sharp to  
 1.5–1.8 m: Aggregate of lateritic fragments  
 1.8–4.3 m: Honey comb structured laterite; [Lat]; gradual to  
 4.3–6.3 m: Laterite; original structure of paleozoic rocks is occasionally seen; [Lat]

**Loc. 155:** ca 5 km NW of Changwat Prachin Buri; 14° 05' 00" N, 101° 20' 50" E  
 G. H.: ca 6 m; slightly undulating tree-less rice land (see Fig. 7)

- Surface–0.2 m: Black (N 2, d) CL; very few dark yl-br (10YR 4/6) fibrous mott; blocky; [BC]; (H: 155–1); sharp to  
 0.2–0.4 m: Pinkish gr (7.5YR 6/2, d) SL; few pale red (10R 6/3) spots; few yl (10YR 7/8) fibrous mott; medium prismatic; [I]; (H: 155–2)  
 0.4–0.5 m: Pinkish gr (5YR 6/2, d) CL; few yl (10YR 8/8) films; few red-yl (7.5YR 7/8) pipes and fibrous mott; very few red (10R 4/8) spots and their aggregates; [I]; (H: 155–3)



**Fig. 7** A NW-SE cross-section of the Bang Pakong valley, showing the recent marine invasion into the valley

**Loc. 156:** ca 9 km SEE of Changwat Prachin Buri; 14° 01' 00" N, 101° 26' 30" E  
 G. H.: 7–10 m; left bank of the Bang Pakong river

- Surface–0.6 m: Gr S; few diffused yl mott  
 0.6–1.0 m: Pinkish gr (7.5YR 6/2, d) LiC; many red (2.5YR 4/8) cloudy mott and aggregates of spots; very few red-yl (7.5YR 7/6) fibrous mott; (H: 156–1)  
 1.0–1.5 m: Dark gr (N 4, d) HC; few red (10R 4/8) small to medium cloudy mott; prismatic; [H: 156–2]  
 1.5–1.8 m: Black (N 2, d) HC; very few red (10R 4/6) spots; [BC]; (H: 156–3)

- 1.8–2.1 m: Olive gr (5Y 5/2, d) HC; few red (10R 4/8) fibrous and cloudy mott; very few yl spots; prismatic; [I]; (H: 156–4)
- 2.1–2.4 m: Light yl-br (10YR 4/6, d) CL; profuse red (10R 4/6 and 4/8) spots and their aggregates; many yl (10YR 7/8) fibrous mott; small to medium blocky; (H: 156–5)
- 2.4–3.0 m: Wh (10YR 8/2, d) SC; common pale red (7.5R 6/4) medium cloudy mott; common yl (10YR 7/8) pipes (replaced plant roots in growing position); stiff; [I]; (H: 156–6)
- 3.0–3.2 m: Wh (10YR 8/2, d) CL; profuse extraneous lateritic fragments and Fe-pisoliths ( $\phi$  2–3 m/m); [II]; (H: 156–7)
- 3.2–3.6 m: Gr (N 6, m) LiC; few to common strong br (7.5YR 5/8) and yl (10YR 7/8) fibrous mott and aggregates of spots; (H: 156–8)
- 3.6–3.7 m: Light gr (N 7, w), red (2.5YR 4/8 and 10R 4/8, w), red-yl (7.5YR 7/8, w) and yl (10YR 8/8, w) mixed SC; profuse Fe-concretions; (H: 156–9)
- 3.7–3.9 m: Wh (N 8, w) CL; profuse yl (2.5Y 7/6), red (7.5R 4/8 and 2.5YR 4/8) and strong br (7.5YR 5/8) spots and cloudy mott; [II]; (H: 156–10)

**Loc. 157:** ca 11 km SEE of Changwat Prachin Buri; 13° 59' 30" N, 101° 26' 50" E  
G. H.: 9–12 m; left bank of the Bang Pakong river

- Surface–0.4 m: Yl-gr medium S; sharp to
- 0.4–0.7 m: Light br-gr (2.5Y 6/2, d) SL; very porous; few charcoal and earthenware fragments; (H: 157–1)
- 0.7–1.2 m: Light br-gr (10YR 6/2, d) SL; profuse red-yl (7.5YR 6/8) pipes and cloudy mott; common irregular shaped Mn-concentrations; (H: 157–2)
- 1.2–1.6 m: Light br-gr (10YR 6/2, d) to br-gr (10YR 5/2, d) SL; common Mn-concentrations; very few charcoal fragments; (H: 157–3)
- 1.6–2.6 m: Light gr (2.5Y 7/2, d), dark yl-br (10YR 4/6) and light yl-br (10YR 6/4) mixed CL; common to many irregular shaped Mn-concentrations with Fe-coating; blocky; (H: 157–4); sharp to
- 2.6–3.4 m: Light gr (2.5Y 7/2, d) SL; many red (2.5YR 4/8) cloudy mott, films and pipes; medium to large prismatic [I]; (H: 157–5)
- 3.4–3.6 m: Dark gr-br (10YR 4/2, m) HC; profuse red (10R 4/8) cloudy mott; many gypsum crystals (1<5 mm); blocky: This clay intercalates wood fragments, one of which is C<sub>14</sub> dated 4030±120 year BP [I]; (H: 157–6)
- 3.6–4.1 m: Light br-gr (10YR 6/2, m) HC; many red (10R 4/8) cloudy mott; few yl (10YR 7/8) fibrous mott and films; many gypsum crystals (1<5 m/m); [I]; (H: 157–7)
- 4.1–4.6 m: Dark olive gr (7.5YR 3/2, m) HC; common yl (2.5Y 8/6) fibrous and filmy mott; [I]; (H: 157–8)
- 4.6–5.2 m: Black (7.5Y 2/2, w) CL; very few yl-red (5YR 3/6) films; profuse plant remains and woods; [I]; (H: 157–9)

**Loc. 158:** ca 1 km W of Amphoe Sri Mahaphot; 13° 58' 20" N, 101° 30' 30" E  
G. H.: 9–12 m; left bank of the Bang Pakong river

- Surface–1.5 m: Unknown
- 1.5–2.2 m: Light gr (2.5Y 7/2, d) SL; many red cloudy mott
- 2.2–3.0 m: Dark br (7.5YR 4/2, d) CL; few red (2.5YR 4/8) spots; angular blocky; (H: 158–1)
- 3.0–3.2 m: Gr C; many red mott; blocky
- 3.2–3.5 m: Br C; many br-yl films and fibrous mott; few red mott
- 3.5–4.1 m: Dark gr-br (10YR 4/2, d) HC; common yl (2.5Y 8/8) films; This clay intercalates many plant remains including a wood fragment which is C<sub>14</sub> dated 6760±145 years BP; [I]; (H: 158–2); sharp to
- 4.1–4.5 m: Wh (10YR 8/2 and 5Y 8/2, d) CL; few yl (2.5Y 8/6) films and fibrous mott; few yl (10YR 7/6) films; common desiccation cracks, whose fillings are the overlying clays (3.5–4.1 m); [I]; (H: 158–3)
- 4.5–4.7 m: Wh (5Y 8/2, d) CL; common to many red (2.5YR 4/8 and 10R 4/8) concentrations and cloudy mott; few olive yl (2.5Y 6/8) and yl (2.5Y 8/8) pipes and films; few weathered coarse sand grains; [I]; (H: 158–4)

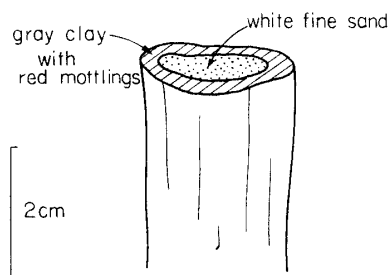
4.7–5.3 m: Wh (10Y 8/2, m) HC; few to common yl (10YR 7/8) cloudy mott; very few strong br (7.5YR 4/6) spots and concretionary mott; [I]; (H: 158–5)

**Loc. 159:** ca 4 km NE of Amphoe Phanom Sarakham; 13° 45' 40" N, 101° 23' 00" E  
G. H.: ca 20 m; strongly undulating bush land (see Fig. 10)

Surface–0.6 m: Very pale br C with common to many quartz grains; gradual to  
0.6–1.0 m: Similar to the above, but many irregular shaped Mn-concentrations (l: 3–10 m/m); clear to  
1.0–1.7 m: White C with common quartz grains; few to common Fe-concentrations ( $\phi$  5–7 m/m); few Mn-concentrations; gradual to  
1.7–2.5 m: White C with common quartz grains; common Fe-concentrations ( $\phi$  1–2 cm); few laterite fragments; very sharp to  
2.5–5.5 m: Lateritized conglomerate [Lat]

**Loc. 160:** ca 1 km SW of Amphoe Phanom Sarakham; 13° 44' 10" N, 101° 20' 30" E  
G. H.: ca 8 m; slightly undulating rice land (see Figs. 8 & 10)

Surface–0.3 m: Wh (10YR 8/2, d) SL; many lateritic fragments; (H: 160–1); sharp to  
0.3–0.45 m: Lateritized clay; pinkish gr (7.5YR 7/2, d) LC; many red (2.5YR 4/8) and yl (10YR 8/8) irregular shaped concretions; [III or older than III]; (H: 160–2); clear but uneven to  
0.45–0.7 m: Pinkish gr (5YR 6/2, d) CL; few red (2.5YR 4/8) diffused cloudy mott; (H: 160–3); occasionally tubular structure as shown in Fig. 8; gradual to  
0.7–1.2 m: Wh (10YR 8/2, d) SL; common to many red (2.5YR 4/8 and 10R 4/8) and yl (10YR 7/8) concretionary mott; well indurated; [III or older than III]; (H: 160–4)



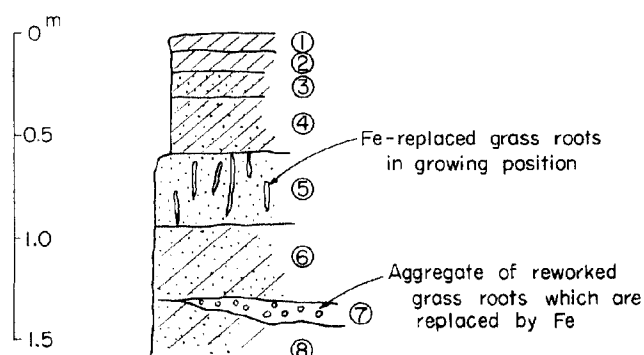
**Fig. 8** One of tubes occasionally found in the 3rd horizon of Loc. 160

**Loc. 161:** ca 2 km SW of Amphoe Phanom Sarakham; 13° 43' 50" N, 101° 20' 00" E  
G. H.: ca 6 m; very slightly undulating tree-less rice land (see Fig. 10)

Surface–0.1 m: Light olive br (2.5Y 5/4, d) SiCL; few red-yl (7.5YR 6/8) fibrous mottlings; (H: 161–1)  
0.1–0.6 m: Br (7.5YR 5/2, D) CL; common red-br (2.5YR 4/4) and red (2.5YR 4/6) spots and their aggregates; few Mn-spots; (H: 161–2)

**Loc. 162:** ca 4 km from Amphoe Phanom Sarakham along the highway to Chachoengsao; 13° 43' 10" N, 101° 19' 20" E  
G. H.: ca 6 m; very slightly undulating tree-less rice land (see Figs. 9 and 10)

- 1) Light br (7.5YR 6/4, d) LIC; very few yl-br (5YR 5/6) films; sharp to
- 2) Br (7.5YR 5/2, d) LiC; few red-yl (7.5YR 6/8) fibrous mott
- 3) Pinkish gr (7.5YR 5/2, d) CL; few to common strong br (7.5YR 5/8) fibrous and cloudy mott; very few red (2.5YR 4/8) spots; prismatic; gradual to
- 4) Similar CL to the above, but more strong br mott; very sharp to



**Fig. 9** A sketch of the outcrop at Loc. 162.

- 5) Wh (10YR 8/2, m) CL; few to common red (7.5R 4/8) spots and their aggregates; few red-yl (7.5YR 7/8) fibrous mott; many Fe-replaced plant roots ( $\phi$  2–20 m/m) in growing position; [I]
- 6) Wh (10YR 8/2, m) CL; few red (10YR 4/8) spots and their aggregates; few red-yl (7.5YR 6/8) spots; [I]
- 7) Aggregates of Fe-replaced plant roots ( $\phi$  2–10 m/m); [I]
- 8) Light gr (5YR 7/2, w) LC; angular; [I]

**Loc. 163:** ca 8 km from Amphoe Phanom Sarakham along the highway to Chachoengsao;

13° 42' 00'' N, 101° 17' 30'' E

G. H.: ca 4 m; flat tree-less rice land (see Fig. 10)

Surface-0.2 m: Black (N 2, m) C; [BC]

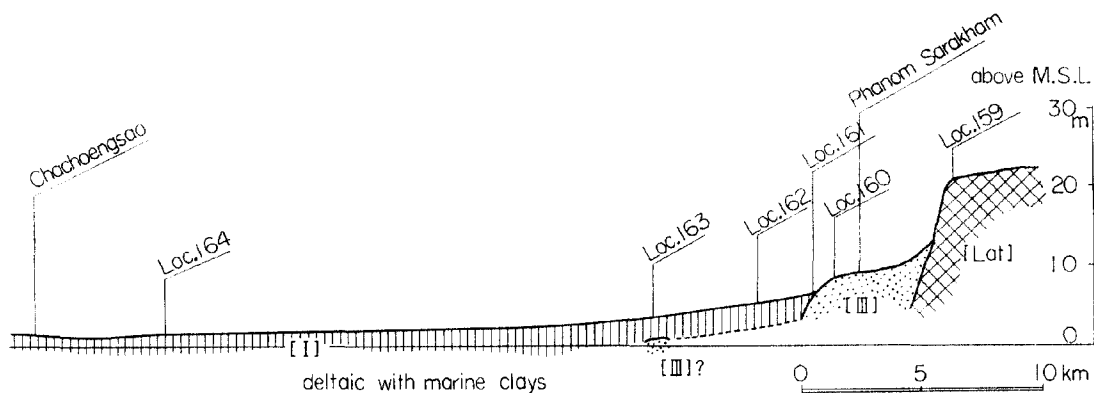
0.2-0.4 m: Very dark gr (N 3, m) C; few to common red (10R 4/8) spots and their aggregates

0.4-0.8 m: Pinkish gr (7.5YR 6/2, m) C; many red (10R 4/8) filmy and cloudy mott; few yl (10YR 7/8) pipes; common Fe-replaced plant roots in growing position; similar to (5) of Loc. 161;  
[1]

0.8–1.1 m: Light br-gr (10YR 6/2, m) to light gr (10YR 7/2, m) C; common yl (10YR 7/8) pipes; very few red (10R 4/8) films

ca 2.8 m: Black (N 2, m) HC; many yl (2.5Y 8/8) films; few plant remains including a wood fragment which is C<sub>14</sub> dated 7440±150 years BP; [I]; (H: 163-1)

Deeper than 3 m: Oxidized SC [III or older than III]



**Fig. 10** An E-W cross-section linking Chachoengsao and Phanom Sarakham, showing the relationship of Quaternary formations in the southeastern margin of the recent delta

**Loc. 164:** ca 6 km SEE of Changwat Chachoengsao; 13° 39' 30" N, 101° 07' 40" E  
G. H.: ca 2 m; flat tree-less rice land (see Fig. 10)

Surface-0.2 m: Black clay [BC]

0.2-0.6 m: Br (7.5YR 5/2, m) C; many red (2.5YR 4/8 and 10R 4/8) spots and their aggregates [I]

0.6-1.1 m: Light gr (10YR 7/2, m) LiC; common red cloudy mott; common yl (10YR 8/8) pipes

1.1-1.6 m: Laminated layers of very fine S and light gr (10YR 7/2, m) C; common pale greenish yl pipes ( $\phi$  2-20 m/m) [I]

**Loc. 165:** ca 6 km NNW of Amphoe Phanat Nikhom; 13° 30' 00" N, 101° 09' 50" E  
G. H.: ca 4 m; slightly undulating rice land

Surface-0.3 m: SC

0.3-1.0 m: Gr (N 6, m) SL; few to common strong br (7.5YR 5/8) and dark br (7.5YR 4/4) small cloudy mott; few Mn-spots

1.0-1.2 m: Dark gr L

1.2-1.6 m: Gr (N 6, m) C and S; few red-yl (7.5YR 4/6) cloudy mott; few pink quartz

**Loc. 166:** ca 1 km SW of Amphoe Phan Thong; 13° 27' 50" N, 101° 05' 40" E  
G. H.: ca 3 m; flat tree-less rice land

Surface-0.05 m: Black Si; common quartz grains [BC]

0.05-0.1 m: Black C; few red (10R 4/8) cloudy mott [BC]

0.1-0.9 m: Br (7.5YR 5/2, m) HC; few yl (2.5Y 8/8) spots, films and pipes; [I]; (H: 166-1)

**Loc. 167:** ca 6 km N of Ayutthaya along the highway leading to Sing Buri;  
14° 24' 20" N, 100° 31' 30" E  
G. H.: ca 2 m; flat tree-less rice land

Surface-3.0 m: See the description of Loc. 8 to Takaya 1971.<sup>2)</sup> A wood fragment produced from a depth of 2 m is C<sub>14</sub> dated 5750 $\pm$ 135 years BP.

**Loc. 168:** ca 3 km N of Ayutthaya; 14° 23' 20" N, 100° 35' 10" E  
left bank of the Pasak river

Surface-3.2 m: See the description of Loc. 9 of Takaya 1971.<sup>2)</sup>

**Loc. 169:** ca 1 km SE of Amphoe Bang Pa In; 14° 12' 50" N, 100° 35' 10" E  
G. H.: ca 2.5 m; slightly elevated plot in broad rice land

Surface-1.1 m: See the description of Loc. 10 of Takaya 1971.<sup>2)</sup>

**Loc. 170:** ca 8 km SWW of Amphoe Wang Noi; 14° 11' 50" N, 100° 39' 20" E  
G. H.: ca 3 m; flat tree-less rice land

Surface-0.1 m: Ploughed layer; dark br-gr C

0.1-0.4 m: Pinkish gr (5YR 6/2, d) C; common red (2.5YR 4/8 and 10R 4/8) films; common yl (2.5Y 8/8) spots; [I]

0.4-1.1 m: Red-gr (5YR 5/2, m) C; common strong br (7.5YR 5/8) pipes and films; few yl (2.5Y 8/8) spots and their aggregates

1.1-1.6 m: Red-gr (5YR 5/2, m) and gr (N 5, m) mixed C; common red concentrations; many plant remains; [I]

1.6-3.1 m: Black (N 2, m) C; few large wood fragments [I]

**Loc. 171:** ca 8 km N of Amphoe Rangsit; 14° 03' 20" N, 100° 32' 10" E  
G. H.: ca 2 m; flat tree-less rice land

Surface-3.5 m: See the description of Loc. 11 of Takaya 1971.<sup>2)</sup>

**Loc. 172:** ca 2 km SE of Amphoe Bang Yai; 13° 50' 20'' N, 100° 26' 20'' E

G. H.: ca 3 m; flat rice land with few palmyra palm trees

Surface–0.1 m: Light br-gr (2.5Y 6/2, d) HC; few red (10R 4/8) and yl (10YR 7/8) spots and their aggregates; few strong br (7.5YR 4/8) cloudy mott; (H: 172–1)

0.1–0.3 m: Gr (N 6, m) HC; few to common red (2.5YR 4/6) medium distinct cloudy mott; profuse gypsum nest; [I] ; (H: 172–2)

0.3–0.4 m: Gr (N 6, m) HC; common red-yl (7.5YR 6/8) medium to large cloudy mott; few gypsum crystals (1 < 5 m/m); (H: 172–3)

0.4–0.5 m: Gr (N 6, m) CL; very few dark br (10YR 3/4) cloudy mott; very few gypsum crystals (1 < 5 m/m); [I]; (H: 172–4)

**Loc. 173:** ca 2.5 km SE of Amphoe Bang Yai; 13° 50' 00'' N, 100° 26' 20'' E

G. H.: ca 3 m; flat rice land with palmyra palm trees

Surface–0.15 m: Gr (N 5, m) LiC; common strong br (7.5YR 5/8) films and fibrous mott; (H: 173–1)

0.15–0.35 m: Gr (N 5, m) LiC; common to many br-yl (10YR 6/6) small to medium cloudy mott; [I]; (H: 173–2); sharp to

0.35–0.55 m: Light br (N 7, m) LiC; common to many very pale br (10YR 7/4) cloudy mott; few dark yl-br (10YR 4/6) spots; very few Fe-concentrations [I]; (H: 173–3)

**Loc. 174:** Pechaburi fly-over bridge, Pratunam, Bangkok; 13° 45' 00'' N, 100° 32' 40'' E

Drilling data reaching to a depth of 32 m: See the description of Loc. 12 of Takaya 1971.<sup>2)</sup>

**Loc. 175:** ca 4 km from Changwat Suphan Buri along the road to Bang Pla Ma;

14° 26' 40'' N, 100° 07' 30'' E

G. H.: ca 3 m; flat rice land

Surface–0.7 m: Pale red (2.5YR 6/2, d) LiC; many red-br (5YR 6/4) small cloudy mott; very few Mn-films and concentrations; (H: 175–1)

0.7–1.1 m: Similar to the above; dark gr (N 4, m) C along cracks; prismatic; (H: 175–2)

1.1–1.4 m: Gr (N 5, m) HC; common to many yl-red (5YR 5/8) and red (2.5YR 4/8) small to medium cloudy mott; (H: 175–3)

1.4–1.7 m: Black (N 2, m) LiC; few red (2.5YR 4/8) small cloudy mott and spots; br (7.5YR 5/2) CL along desiccation cracks; [BC]; (H: 175–4)

1.7–2.0 m: Gr (N 6, m) HC; common to many red (2.5YR 4/8) spots and their aggregates; very few br-yl (10YR 6/6) fibrous mott; few gypsum nests; indurated; [III or the older than III]; (H: 175–5)

2.0–2.3 m: Pinkish gr (5YR 6/2, w) HC; few to common red (2.5YR 4/8) medium cloudy and few yl (10YR 7/8) fibrous mott; black (N 2) C along cracks; many pressure faces; indurated; [III or older than III]

**Loc. 176:** ca 5 km SEE of Changwat Suphan Buri; 14° 25' 30'' N, 100° 09' 00'' E

G. H.: ca 3 m; flat tree-less rice land

Surface–0.5 m: Wh (2.5YR 7/2, d) SCL; many red (2.5YR 5/8 and 4/8) small to medium cloudy mott; few red-yl (7.5YR 6/8) cloudy mott; many muscovite flakes; porous; (H: 176–1); sharp to

0.5–1.5 m: Gr (N 6, m) HC; profuse red (2.5YR 5/6) and red-br (2.5YR 4/4) cloudy mott; common gypsum crystals (1 < 10 m/m); well indurated; strong angular blocky; [III or older than III]; (H: 176–2)

**Loc. 177:** ca 9 km from U Thong along U Thong-Suphan Buri road; 14° 24' 20'' N,

99° 97' 40'' E

G. H.: ca 6 m; slightly undulating rice land

Surface–0.2 m: Ploughed layer

0.2–0.5 m: Very dark br (10YR 2/2, m) and dark br (7.5YR 3/4, m) finely mixed HC; few red (2.5YR 4/6) spots; very few light yl-br (10YR 6/4) cloudy mott; very few gypsum needles; [BC]; (H: 177–1)

**Loc. 178:** ca 8 km from U Thong along U Thong-Suphan Buri road; 14° 24' 00" N, 99° 57' 40" E

G. H.: ca 6 m; slightly undulating rice land

Surface–0.5 m: Light br-gr (2.5Y 6/2, d) HC; very few Mn-pisoliths ( $\phi$  1–2 m/m) (H: 178–1); gradual to 0.5–1.2 m: Black (N 2, m) HC; very few red-yl (7.5YR 6/8) films; common gypsum crystals; indurated; strong angular blocky; [III or older than III]; (H: 178–2)

**Loc. 179:** ca 4 km NNE of Amphoe Phanom Thuan; 14° 09' 10" N, 99° 43' 10" E

G. H.: ca 19 m; undulating upland crop field

Surface–1.2 m: Gr-br (10YR 5/2, d) SL; Common muscovite flakes; (H: 179–1); sharp to

0.2–1.2 m: Yl-br (10YR 5/4, d) CL; profuse yl-red (10R 5/6) and red-yl (5YR 7/6) concretionary to cloudy mott; very few Mn-pisoliths; very few muscovite flakes

1.2–2.7 m: Unknown

2.7–3.2 m: Wh (10YR 8/2, d) and very pale br (10YR 7/4) mixed HC; few Mn-films; spots and pisoliths; common Ca-nodules

**Loc. 180:** 0.5 km W of Tha Muang; 13° 58' 20" N, 99° 38' 30" E

Left bank of the Mae Nam Mae Khlong

Surface–1.5 m: Loamy staff

1.5–2.5 m: Light yl-br (10YR 6/4, d) LiC; profuse red-yl (7.5YR 6/6) cloudy mott; few muscovite flakes; gradual to

2.5–4.0 m: Light gr (2.5Y 7/2, d) LiC; common Mn-concentrations; few red-yl (7.5YR 7/6) cloudy mott; few Ca-nests; very few Mn-pisoliths ( $\phi$  1–2 m/m); many quartz grains; few to common feldspar grains [I]

4.0–4.4 m: Aggregates of Mn-pisoliths; Ca-nodules and Fe-concretions; sharp to

4.4–5.3 m: Pale yl (2.5Y 7/4, d) LiC; few br-yl (10YR 6/6) cloudy mott; few strong br (7.5YR 5/8) concretionary mott; few irregular shaped Mn-concentrations; very few Fe-pisoliths; few Ca-nodules ( $\phi < 5$  cm); [III]; gradual to

5.3–5.5 m: Gravel and coarse S

5.5–6.7 m: Wh (5Y 8/2, d) CL; profuse Ca-spots; few strong br (7.5YR 5/8) concretionary and cloudy mott; very few Mn-films

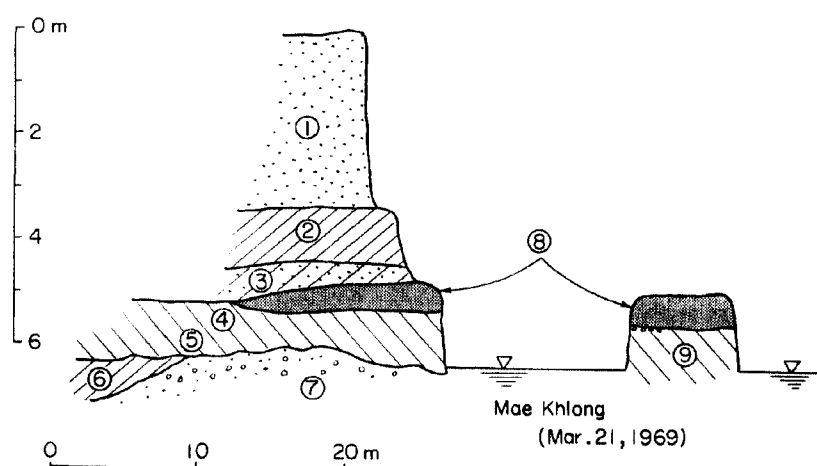
6.7–7.7 m: Light gr (5Y 7/2, d) SL; few strong br (7.5YR 5/8) large cloudy mott; common muscovite flakes; well indurated; Ca-nodules along joints [III]

**Loc. 181:** ca 21 km NW of Amphoe Ban Pong; 13° 57' 50" N, 99° 44' 30" E

Left bank of the Mae Nam Mae Khlong (see Fig. 11)

- 1) Loose and fresh S
- 2) Gr (N 6, d) C; common to many Ca-nodules ( $\phi$  5–10 m/m); common yl-br (10YR 5/6) cloudy mott; few extraneous Fe-pisoliths
- 3) Wh (10YR 8/2, d) CL; few red (2.5YR 5/6) spots; few yl-br (10YR 5/8) cloudy mott; very few Fe-pisoliths ( $\phi$  2–3 m/m)
- 4) Wh (5YR 8/2, d) CL; few red (2.5YR) spots; few Ca-nests; few Fe-pisoliths
- 5) Wh (N 8, m) C; few strong br (7.5YR 5/6) concretions
- 6) Light gr (N 7, w) LiC; many strong br (7.5YR 5/8) cloudy mott
- 7) Coarse S with pebble; indurated
- 8) Aggregates of Ca-nodules ( $\phi$  5–10 m/m) and Mn-pisoliths ( $\phi$  2–3 m/m); very few Fe-pisoliths
- 9) Wh (10YR 8/2, d) C; many red (2.5YR 5/6) concretions; Mn-concretions ( $\phi < 10$  m/m); common Ca-nodules ( $\phi < 15$  cm); well indurated

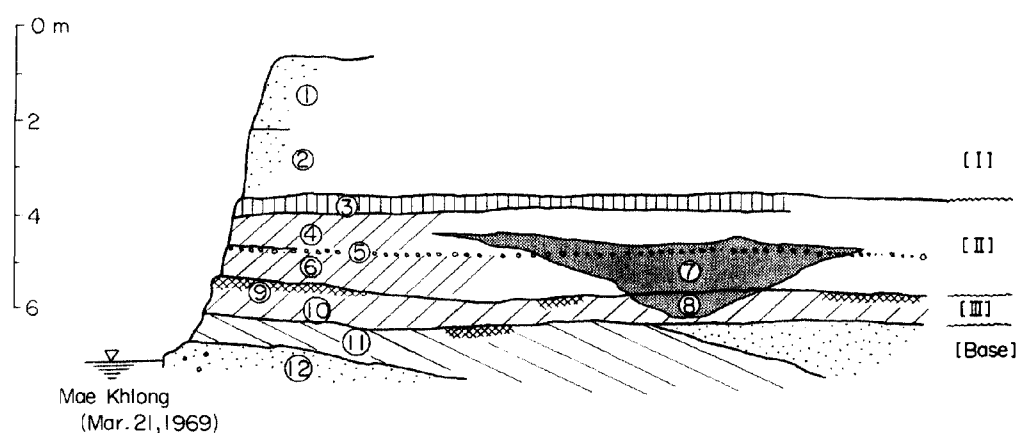




**Fig. 11** A sketch of the outcrop at Loc. 181

**Loc. 182:** ca 13 km NW of Ban Pong; 13° 53' 50" N, 99° 47' 30" E  
Left bank of the Mae Nam Mae Khlong (see Fig.12)

- 1) Light yl-br (10YR 6/4, d) S with mica flakes
- 2) Light yl-br (10YR 6/4, d) and light gr (10YR 7/2) mixed L; common Ca-cemented CS
- 3) Gr (N 6, d) CL; few strong br (7.5YR 5/8) cloudy mott
- 4) Light gr (5YR 7/2, d) and light yl-br (10YR 6/4) mixed L; common quartz grains
- 5) Accumulation of extraneous Fe-pisoliths and gravels
- 6) Wh (10YR 8/2, d) CL; profuse fine quartz grains; few extraneous lateritic fragments; indurated
- 7) Pocket of Mn- and Ca-nodules
- 8) Mn- and Ca-concentrating pocket in (10)
- 9) Lateritic pan; not continuous
- 10) Wh (10YR 8/2, d) CL; few quartz grains; common yl-br spots and aggregates
- 11) Wh (5Y 8/2, d) LC; few fine quartz grains; common to many red (10R 5/8) spots and their aggregates
- 12) Coarse S with pebble ( $\phi < 10$  m/m); many yl-red (5YR 5/8) big mott; few Mn-films



**Fig. 12** A sketch of the outcrop at Loc. 182

**Loc. 183:** ca 1 km S of Amphoe Ban Pong; 13° 48' 20" N, 99° 52' 40" E  
Left bank of the Mae Nam Mae Khlong

Surface–2.0 m: Light yl-br (10YR 6/4, d) S  
2.0–3.0 m: Pale yl (2.5Y 7/4, d) LiC; common pink (7.5YR 7/4) diffused small films; few light red-br (5YR 6/4) films  
3.0–3.2 m: Light olive gr (2.5Y 6/2, d) LiC; few pale yl (2.5Y 7/4) cloudy mott; few strong br (7.5YR 5/8) spots; few Mn-films  
3.2–5.5 m: Light gr (N 7, d) very pale br (10YR 7/4) and yl-br (10YR 5/8) finely mixed CL; occasionally plant remains  
5.5–5.8 m: Gr (N 6, d) LiC; few light yl-br (10YR 6/4) cloudy mott  
5.8–6.0 m: Light gr (N 7, d) and br-yl (10YR 6/6) mixed LiC [I]  
6.0–6.3 m: Dark gr (N 4, m) CL; few extraneous Fe-pisoliths; very few yl-br (10YR 5/6) cloudy mott; very few Ca-spots; this units occasionally intercarates pockets of Mn-pisoliths and Ca-nodules  
6.3–6.7 m: CS with profuse pink quartz gains; indurated [III]

**Loc. 184:** ca 25 km N of Nakhon Pathom along the road to U Thong 14° 01' 40" N, 99° 59' 40" E  
G. H.: ca 6 m; undulating land having paddy lands in depressional parts

Surface–0.3 m: Dark gray sandy part  
0.3–1.5 m: Coarse S with gravel ( $\phi < 4$  m/m); common hydromica and muscovite flakes; partly well indurated by ground water lateritization [I or younger than I]

**Loc. 185:** ca 9 km NW of Nakhon Pathom; 13° 52' 30" N, 100° 00' 00" E  
G. H.: ca 6 m; undulating bush land

Surface–0.3 m: Dark gray sandy part; sharp boundary to  
0.3–0.7 m: Yl-gr and gr-br mixed LiC; many irregular shaped Mn-concentrations with Fe-coating; gradual boundary to  
0.7–1.4 m: Yl-gr and gr-br mixed LiC; very few Ca-nodules ( $l < 15$  m/m); gradual to  
1.4–1.8 m: Gr-br (10YR 5/2, m) LiC; few yl-red (5YR 3/6) concretionary mott; few strong br (7.5YR 5/8) cloudy mott; very few fine Ca-nodules [I equivalent] (H: 148–1)

**Loc. 186:** ca 6 km NW of Nakhon Pathom; 13° 52' 40" N, 99° 59' 40" E  
G. H.: ca 6 m; very slightly undulating rice land

Surface–0.7 m: Light br-gr (10YR 6/2, d) and light yl-br (10YR 6/4) finely mixed CL; many yl-br (10YR 5/8) spots; very few Mn-concentrations ( $\phi$  2–3 m/m); [I equivalent]  
0.7–1.1 m: Gr (N 6, d) LiC; very few strong br (7.5YR 5/8) spots; very few fine Ca-plate shaped crystals  
1.1–1.4 m: Light gr (N 7, d) LiC; common small to medium br-yl (10YR 6/6) cloudy mott; common Mn-films; few Ca-crystals ( $l < 7$  m/m)  
1.4–1.9 m: Light gr (N 7, d) LiC; few to common weak red (10R 5/4) concretionary mott; many gypsum crystals ( $l < 5$  m/m)  
1.9–2.2 m: Dark gr to very dark gr (N4–N3, m) HC; many red (10R 4/8) films; few red-yl (7.5YR 6/8) fibrous mott; many gypsum crystals  
2.2–2.4 m: Dark gr-br (10YR 4/2, m) HC; common yl (2.5Y 8/8) pipes and fibrous mott; few gypsum crystals  
2.4–2.9 m: Dark gr-br (10YR 4/2, m) to pinkish gr (7.5YR 6/2, d) HC; few plant remains; few gypsum crystals; [I]

**Loc. 187:** ca 1 km W of Changwat Nakhon Pathom; 13° 48' 50" N, 100° 02' 30" E  
G. H.: ca 5 m; a flower garden

Surface–0.1 m: Very dark gr (N 3, m) LS; few yl-red (5YR 5/8) fibrous and yl-br (10YR 5/4) cloudy mott; few muscovite flakes; (H: 187–1)  
 0.1–0.3 m: Dark gr-br (2.5Y 4/2, m) and olive br (2.5Y 4/4, m) SL; few red-yl (7.5YR 6/8) cloudy mott; common muscovite; (H: 187–2)  
 0.3–0.65 m: Gr-br (10YR 5/2, m) SiCL; few br-yl (10YR 6/6) spots and cloudy mott; few muscovite; very few fine Mn-concretions; few Ca-nodules ( $1 < 10$  m/m); (H: 187–3)  
 0.65–0.8 m: Dark gr (N 4, m) HC; common red-yl (7.5YR 6/6) cloudy mott; few plant remains; (H: 187–4)  
 0.8–1.0 m: Very dark gr (N 3, m) LiC; very few light yl-br (2.5Y 6/4) cloudy mott; very few Fe-concentrations; few needle-shaped crystals; (H: 187–5)  
 1.0–1.4 m: Light gr (N 7, m) HC; common to many red (2.5YR 4/8) and yl (10YR 7/8) cloudy mott; very few Mn-pisoliths ( $\phi$  3 m/m); few muscovite; common gypsum crystals ( $1 < 10$  m/m); fillings of N3 LiC from the above in desiccation cracks; (H: 187–6)  
 1.4–1.8 m: Gr (N 6, m) HC; many to profuse red (10R 4/8) films; few light olive gr (7.5Y 6/2) films; few yl (10YR 7/8) spots and fibrous mott; very few muscovites; few gypsum needles ( $1 < 7$  m/m); (H: 187–7)  
 1.8–2.1 m: Gr-br (10YR 5/2, m) LiC; few yl (2.5Y 8/8) pipes; few needle-shaped crystals [I]; (H: 187–8)  
 2.1–2.4 m: Dark gr-br (10YR 4/2, m) C; few dark gray (N 3) clay balls; common needle-shaped crystals; very few plant leaf remains; (H: 187–9)  
 2.4–3.4 m: Alternated layers of black (N 2, m) C and S; sandy parts produce wood fragments, one of which is C<sub>14</sub> dated  $5670 \pm 135$  years BP, and shells; [I]; (H: 187–10)  
 3.4–3.9 m: Thinly laminated fine S and C; [I]; (H: 187–11)

**Loc. 188:** ca 8 km E of Nakhon Pathom; 13° 48' 30" N, 100° 07' 30" E

G. H.: ca 3 m; flat rice land with few palmyra palm trees

Surface–0.2 m: C; common loose Mn-concretions ( $\phi$  1–6 m/m); large prismatic  
 0.2–0.5 m: Dark gr-br (2.5Y 4/2, d) HC; few to common yl-br (10YR 5/4) medium cloudy mott; [I]; (H: 188–1)

**Loc. 189:** ca 3 km W of Amphoe Nakhon Chaisi; 13° 48' 10" N, 100° 09' 50" E

G. H.: ca 3 m; flat rice land with many palmyra palm trees

Surface–0.1 m: Olive gr (2.5Y 5/2, d) CL; few red-yl (6YR 6/8) fibrous mott  
 0.1–0.3 m: Very dark gr (N 3, d) LiC; very few red-yl (7.5YR 6/8) spots  
 0.3–0.5 m: Olive gr (5Y 5/2, d) CL; few loose Fe-concretions ( $\phi$  2–3 m/m); few loose Mn-pisoliths ( $\phi$  2–3 m/m); [I]  
 0.5–0.9 m: Laminated layers of light gr (N 7, m) C and fine S; many mica flakes; common Ca-crystals; few fragments of shell and crab claw; [I]

**Loc. 190:** 0.5 km E of Sala Ya railway station; 13° 48' 00" N, 100° 20' 00" E

G. H.: ca 3 m; flat tree-less rice land

Surface–0.4 m: Black (N2, m) HC; few red-yl (7.5YR 6/8) films and fibrous mott; few gypsum crystals [BC]; (H: 190–1); gradual to  
 0.4–0.5 m: Gr (N6, m) HC; common Mn-spots; few Mn-concretionary mott; profuse gypsum crystals; [I]; (H: 190–2)

**Loc. 191:** ca 11 km N of Damnoensadwak; 13° 56' 50" N, 99° 56' 30" E

G. H.: ca 7 m; very slightly undulating tree-less rice land

Surface–0.3 m: Black (N2, m) CL [BC]; (H: 191–1)  
 0.3–0.7 m: Br-yl (10YR 6/8, m) and light br-gr (2.5Y 6/2) mixed SiCL; few muscovite; angular blocky [I]; (H: 191–2); gradual to

0.7–1.5 m: Similar to the above; but slightly more grayish [I]; (H: 191–3)  
 1.5–1.8 m: Light gr (2.5Y 7/2, m) SL; many muscovite flakes; few shell fragments [I]; (H: 191–4)

**Loc. 192:** ca 7 km N of Damnoensadwak; 13° 45' 00" N, 99° 58' 10" E  
 G. H.: ca 7 m; very slightly undulating tree-less paddy land

Surface–0.4 m: Black (2.5Y 2/2, m) HC; few loose Mn-concretions ( $\phi$  2–3 m/m) [BC]; (H: 192–1)  
 0.4–0.9 m: Light olive gr (5Y 6/2, m) CL; few dark yl-br (10YR 4/6), yl-br (10YR 5/6) and br-yl (10YR 6/8) mixed cloudy mott; few loose Mn-concretions; few muscovite; few Ca-crystals; [I]; (H: 192–2)  
 0.9–1.3 m: Light yl-br (2.5Y 6/4, m) S; few to common yl-br (10YR 5/4–5/8) cloudy mott; common large muscovite flakes; few shell fragments; [I]; (H: 192–3)

**Loc. 193:** ca 2 km NE of Damnoensadwak; 13° 41' 50" N, 99° 58' 20" E  
 G. H.: ca 6 m; Vegetable garden reclaimed from Nipa swamp

Surface–0.9 m: Black (2.5Y 2/2, d) HC; very few shell fragments; [I]; (H: 193–1)  
 0.9–1.9 m: Dark greenish gray (5GY 4/2, w) HC; few shell fragments; [I]; (H: 193–2)

**Loc. 194:** ca 9 km from Rat Buri along a highway to Nakhon Pathom; 13° 45' 20" N, 99° 56' 50" E  
 G. H.: ca 6 m; slightly undulating rice land with many abandoned river courses

Surface–0.2 m: Dark gr-br (2.5Y 4/2, m) SiCL; few to common yl-red (5YR 4/8) fibrous mott and spots; [I]; (H: 194–1)  
 0.2–0.7 m: Very dark gr (N 3, m) HC; few strong br (7.5YR 5/6) diffused small to medium cloudy mott; [I]; (H: 194–2)  
 0.7–1.2 m: Black (7.5YR 2/2, m) HC; few yl-br (5YR 4/8) fibrous mott and spots; few gypsum crystals; [I]; (H: 194–3)  
 1.2–1.5 m: Pinkish gr (5YR 7/2, m) HC; common to many yl-br (5YR 4/8) and red-yl (7.5YR 5/8) fibrous mott; [I]; (H: 194–4)

**Loc. 195:** ca 5 km SE of Rat Buri; 13° 30' 40" N, 99° 51' 40" E  
 G. H.: ca 3 m; slightly undulating rice land

Surface–0.1 m: Dark gr C; few br-yl fibrous mott  
 0.1–0.4 m: Dark gr (N 4, m) HC; few br-yl (10YR 6/6) patches; [I]; (H: 195–1)  
 0.4–0.9 m: Light olive gr (7.5Y 6/2, m) HC; partly olive gr (5Y 4/2); common strong br (7.5YR 5/8) cloudy mott; few Mn-films and spots; [I]; (H: 195–2)

**Loc. 196:** ca 6 km SE of Rat Buri; 13° 30' 10" N, 99° 51' 40" E  
 G. H.: ca 3 m; slightly undulating rice land

Surface–0.2 m: Dark br (7.5YR 4/2, m) SL; few to common red (2.5YR 4/8) concretionary mott; few yl-br (10YR 5/4) cloudy mott; few gypsum crystals; [I]; (H: 196–1)  
 0.2–0.6 m: Pinkish gr (7.5YR 7/2, d) SL; many coarse sand grains and common gravels; common to many red (10YR 4/8) cloudy mott; common red-yl (7.5YR 7/8) pipes and cloudy mott; few yl (7.5YR 7/8) fibrous mott; many gypsum crystals; common shell fragments; [I]; (H: 196–2)

**Loc. 197:** ca 7 km SE of Rat Buri, 13° 29' 50" N, 99° 51' 50" E  
 G. H.: ca 3 m

Surface–0.4 m: Wh (10YR 8/2, d) fine S; very few light yl-br (2.5Y 6/4) cloudy mott; very few red-yl (7.5YR 6/8) concretionary mott; (H: 197–1)

**Loc. 198:** 3 km NWW of Amphoe Pak Tho; 13° 23' 00" N, 99° 49' 20" E  
G. H.: ca 8 m; slightly undulating rice land

Surface–0.2 m: Br (7.5YR 5/2, d) CL; common to many red-yl (7.5YR 6/8) fibrous mott; (H: 198–1); sharp to

0.2–0.3 m: Aggregates of lateritic fragments; [III]; (H: 198–2)

0.3–0.7 m: Pale yl (2.5Y 7/4, d) CL; common to many br-yl (10YR 6/6–6/8) cloudy mott; few Fe-pisoliths ( $\phi$ 1–3 m/m); [III]; (H: 198–3)

0.7–1.3 m: Pale yl (2.5Y 7/4, d) and light gr (N 7, d) laminated CL; few strong br (7.5YR 4/6) spots and concretionary mott; few Fe-pisoliths; [III]; (H: 198–4)

**Loc. 199:** ca 2 km W of Bang Khem Station; 13° 17' 50" N, 99° 50' 10" E  
G. H.: ca 5 m; slightly undulating rice land

Surface–0.5 m: Dark olive gr (2.5Y 3/2, m) SiC; no mottlings; few shell fragments; (H: 199–1)

**Loc. 200:** ca 4 km E of Changwat Phet Buri; 13° 07' 00" N, 99° 54' 30" E  
G. H.: ca 3 m; slightly undulating rice land with many palmyra palm trees

Surface–0.2 m: Very dark br (10YR 2/2, m) LiC; common to many red (2.5YR 4/8) spots and their aggregates

0.2–0.4 m: Very dark br (10YR 2/2, m) HC; common red (2.5YR 4/8) spots and their aggregates; few Fe-concretionary mott; common fine gypsum crystals; [I]

0.4–0.5 m: Li gr (2.5Y 7/2–5Y 7/2, m) SL to SiCL; few pale yl (2.5Y 7/2) cloudy dark yl-br (10YR 4/6) fibrous mott; few muscovite flakes; very few plant remains; profuse gypsum crystals; [I]

0.5–1.0 m: Li gr (7.5YR 7/2, m) medium to coarse S; few yl-red (5YR 4/6) pipes; many muscovite and few hydromica flakes; [I]

1.0–1.4 m: Li gr (2.5Y 7/2–10YR 7/2, m) S; common to many yl (10YR 7/8) pipes, films and cloudy mott; few red (2.5YR 4/8) pipes; few to common gypsum crystals; [I]

1.4–1.6 m: Laminated br-gr fine S and C; a few cross-laminated lignite seams; [I]

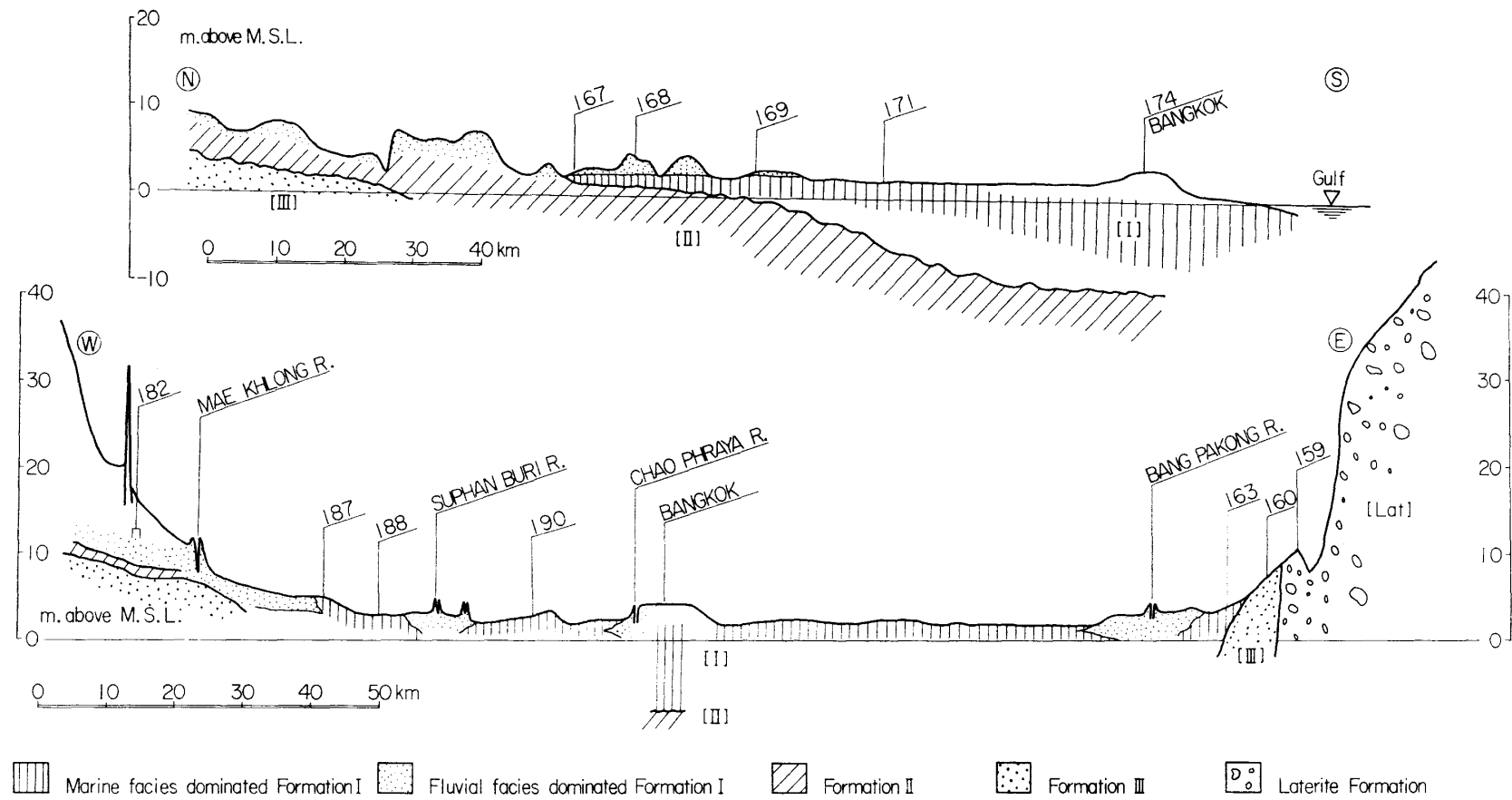
1.6–1.8 m: Black (N 2, m) C; few S seams; few wood fragments

### III Summary

Two representative cross-sections are shown in Fig. 13.

Laterite Formation which is mostly composed of lateritized gravels has an extensive distribution in the southeastern marginal zone of the plain, and this extends further eastwards into the Tonle Sap basins beyond the divide of the Chao Phraya drainage basin. Since this distribution has little affinity with the existing river system, the age seems to the author to be considerably old, possibly early Pleistocene to the late Pliocene.

Formation III is ubiquitous throughout the marginal zones of the plain, having the form of semi-fossilized fans. But since this is often overlaid by younger deposits of fan type, it is difficult to show the exact configuration separately from the other formations.



**Fig. 13** N-S (above) and E-W (below) cross-sections through Bangkok, showing the relationships of Quaternary formations

Formation II, by contrast, has its own domain in the old delta area, which is approximately 100 to 200 km inland from the present shore line. This formation has both fluvial and marine facies of the deltaic environment. The age is temporarily considered to be of last interglacial<sup>2)</sup> based on the stratigraphical relations with the recent deposits.

Marine and brackish sediments which comprises the important parts of the Formation I of this area are seen abutting the above-mentioned Pleistocene formations. The ages of some of these sediments are C<sub>14</sub>-dated as follows;

Years B.P.	Localities
4030 $\pm$ 120	Loc. 157 : ca 11 km SEE of Prachin Buri
6760 $\pm$ 145	Loc. 158 : ca 1 km W of Sri Mahaphot
7440 $\pm$ 150	Loc. 163 : ca 8 km SW of Phanom Sarakham
5750 $\pm$ 135	Loc. 167 : ca 6 km NW of Ayutthaya
5670 $\pm$ 135	Loc. 187 : ca 1 km W of Nakhon Pathom

These post-glacial marine and brackish sediments, which are usually of dark greenish to dark brownish gray color and are often accompanying gypsum crystals and yellow mottlings, interfinger with fluvial sediments brought down by such big rivers as the Chao Phraya and the Mae Khlong. The Chao Phraya fluvium develops as levee and back swamp deposits of somewhat more brownish color. The Mae Khlong river, on the other hand, spreads its loads into the area forming landform of a fan.

Though most part of the recent deltaic area seems to have been kept stable, some of the peripheral parts likely suffered from structural disturbance. Such abnormally high elevations of recent brackish clays like at Locs. 156, 157 and 158, and some peculiar rectilineal topographic arrangement observed in the area are taken as the evidence of the recent tectonic disturbance.

Calcareous Formation seems to be a kind of Kanker deposits formed in such older rocks as Paeleozoic calcareous shale and Tertiary volcanic rocks. The ground surface of the formation is dissected and undulating like that of the Laterite formation. This suggests that the surface itself was formed some time in early Quaternary. But this does not necessarily mean that the deposits are this old. The author supposes that the deposition has been developing intermittently through the Quaternary period and is developing even at the present moment. So far not many things are made clear, except for that the formation is affinitive to the Paeleozoic limestone rocks.

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